

**LEAD SOIL TREND ANALYSIS  
THROUGH MARCH 2004  
Herculaneum Lead Smelter Site  
Herculaneum, Missouri**



Tetra Tech EM Inc. (Tetra Tech) was tasked by the U.S. Environmental Protection Agency (EPA) Region 7 Enforcement Fund Lead Removal program to conduct a trend analysis of soil lead concentrations at selected locations within Herculaneum, Missouri (City). Specifically, the Tetra Tech Superfund Technical Assessment and Response Team (START) 2 was requested to review and analyze data that would enable EPA to determine if soil lead concentrations were increasing over time at a variety of locations within the City. Tetra Tech had previously performed this analysis and was requested to repeat the analysis and include the most current sampling round data. The assessment was conducted under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986. The project was assigned under START Contract No. 68-S7-01-41, Task Order No. 0027.

Tetra Tech focused its analysis on one data set called "Recontamination." This data set includes results from a number of locations. The data were collected from four different quadrants at each property, and several properties also included samples from a driveway area. Lead concentrations were estimated at each location at approximately monthly intervals after the remediation was completed until March 2004 (Round 16). Due to the sequence of remediation, not all properties had the same number of sampling events; the number of events ranged from 4 to 10 events per resident. At many locations, some intervals within the series were omitted due to weather or access restrictions. The lead concentrations were determined by use of a portable X-ray fluorescence (XRF) instrument. Samples were collected and analyzed in accordance with the quality assurance project plan (QAPP) dated September 11, 2001.

This document presents the methods used to evaluate changes in lead soil concentrations since each property was remediated and the results of this analysis.

## **Methods**

Temporal trends in lead concentrations for 21 properties are summarized in Table 1. Trend tests were conducted for each property using all data collected from round 7 (August 2002) and thereafter. The

non-parametric Mann-Kendall test was used to evaluate temporal trends for individual properties. The Mann-Kendall test is a widely used statistical test for detecting monotonic trends (that is, trends that are either increasing or decreasing) in time-series of data (Gilbert 1987; Helsel and Hirsch 1992; Gibbons 1994). Because the Mann-Kendall test uses only the relative magnitude of the data rather than their measured values, it has a number of desirable properties: the data do not need to be normally distributed; and the test is not significantly affected by outliers, missing data, or censored data. Censored data are normally treated in the Mann-Kendall test by setting all non-detect values to a concentration slightly below the minimum detected concentration. However, because this analysis was conducted for pooled measurements from each of the four quadrants for each property, only the median concentrations for each sampling round were considered. Each median value was effectively treated as a detected measurement for the purpose of this analysis. It should be noted that a minimum of four sampling events are required to perform this test, so properties with fewer than four rounds of sampling were not evaluated.

## **Results**

The analysis of temporal trends in lead concentration identified four properties with a statistically significant trend, House Numbers 20, 5, 22, and 8. All locations except House Number 8 were within 0.25 miles of the smelter. The data analysis from the previous sampling round showed six homes with an increasing trend. Based on the most current results, House Numbers 9 and 17 no longer exhibit a statistically significant increasing trend in lead concentrations.

## **References:**

- Gibbons, R. D. 1994. *Statistical Methods for Groundwater Monitoring*. John Wiley & Sons, Inc. New York, New York.
- Gilbert, R. O. 1987. *Statistical Methods in Environmental Pollution Monitoring*. John Wiley & Sons, Inc. New York, New York.
- Helsel, D. R. and R. M. Hirsch. 1992. *Statistical Methods in Water Resources*. Elsevier. New York, New York.

**TABLE 1**  
**RESULTS OF STATISTICAL TESTING FOR MONOTONIC TRENDS (MANN-KENDALL TEST) IN LEAD CONCENTRATION.**  
**PROPERTIES ARE ORDERED IN INCREASING DISTANCE FROM THE SMELTER.**

Distance From Smelter	House Number	Address	Number of Sampling Events	Sampling Event		Test Statistic (S)	Probability > S	Trend Significant? (Yes/No)	Direction of Trend
				First	Last				
0.20	20	928 Church	9	08/26/2002	03/22/2004	28	0.00	Yes	Increasing
0.25	5	407 Burris	9	08/26/2002	03/22/2004	26	0.00	Yes	Increasing
0.25	6	907 Dale	9	08/23/2002	03/22/2004	12	0.13	No	N/A
0.25	22	824 Brown	8	08/26/2002	03/22/2004	22	0.00	Yes	Increasing
0.25	24	812 Brown	7	11/07/2002	03/22/2004	6	0.24	No	N/A
0.40	12	292 Park	10	08/23/2002	03/22/2004	14	0.13	No	N/A
0.40	13	562 Reservoir	7	08/23/2002	06/23/2003	3	0.39	No	N/A
0.40	17	416 Thurwell	9	08/22/2002	03/22/2004	12	0.13	No	N/A
0.40	21	295 Broadway	6	08/23/2002	03/23/2004	5	0.24	No	N/A
0.45	11	525 Joachim	5	08/26/2002	03/17/2003	0	0.59	No	N/A
0.50	14	440 Thurwell	5	09/16/2002	06/23/2003	-2	0.41	No	N/A
0.50	16	695 Joachim	7	09/16/2002	03/22/2004	10	0.09	No	N/A
0.50	19	407 Hill	9	08/22/2002	03/22/2004	0	0.54	No	N/A
0.54	9	454 Hill	9	08/22/2002	03/22/2004	12	0.13	No	N/A
0.60	4	438 Washington	6	08/22/2002	03/14/2003	2	0.43	No	N/A
0.60	18	422 Reservoir	10	08/23/2002	03/22/2004	11	0.19	No	N/A
0.75	3	441 Main	10	08/23/2002	03/22/2004	12	0.17	No	N/A
0.75	10	485 St. Joseph	6	08/22/2002	03/14/2003	2	0.43	No	N/A
0.75	23	404 Jefferson	4	10/08/2002	01/13/2003	3	0.27	No	N/A
0.80	7	434 Sherman	10	08/23/2002	03/22/2004	17	0.08	No	N/A
1.00	8	157 Joachim	6	08/23/2002	03/17/2003	13	0.01	Yes	Increasing

**Notes:**

Trend tests were not conducted with fewer than four rounds of sampling (these properties are not included in the table).  
Trend testing was conducted using the median concentration for each sampling round (median of pooled quadrants).  
Monotonic trends are significant for probabilities less than or equal to 0.05.  
Significant negative values for the Mann-Kendall test statistic indicate that trends are decreasing.  
Significant positive values for the Mann-Kendall test statistic indicate that trends are increasing.

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